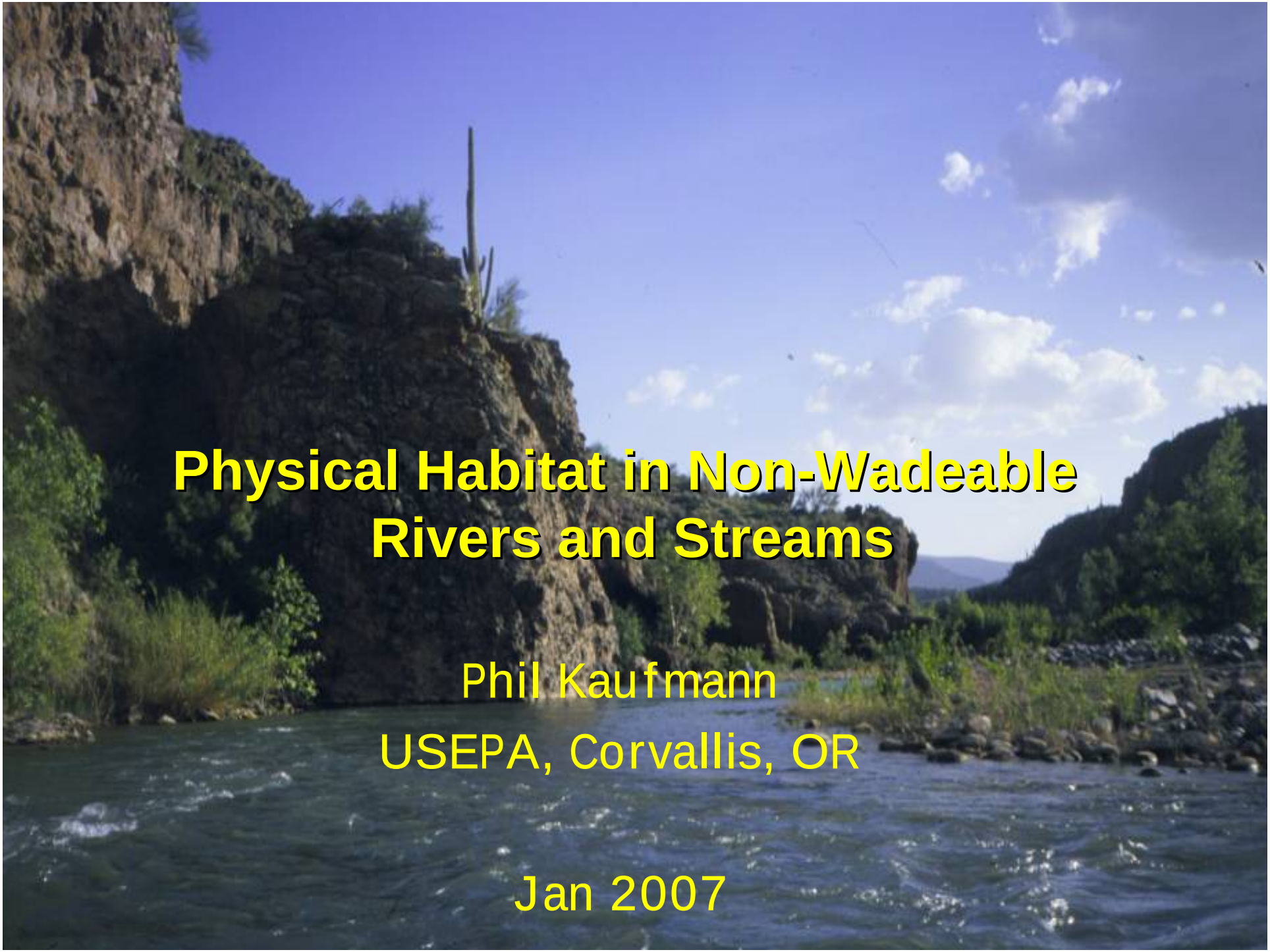

Physical Habitat in Non-Wadeable Rivers and Streams

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Jan 2007

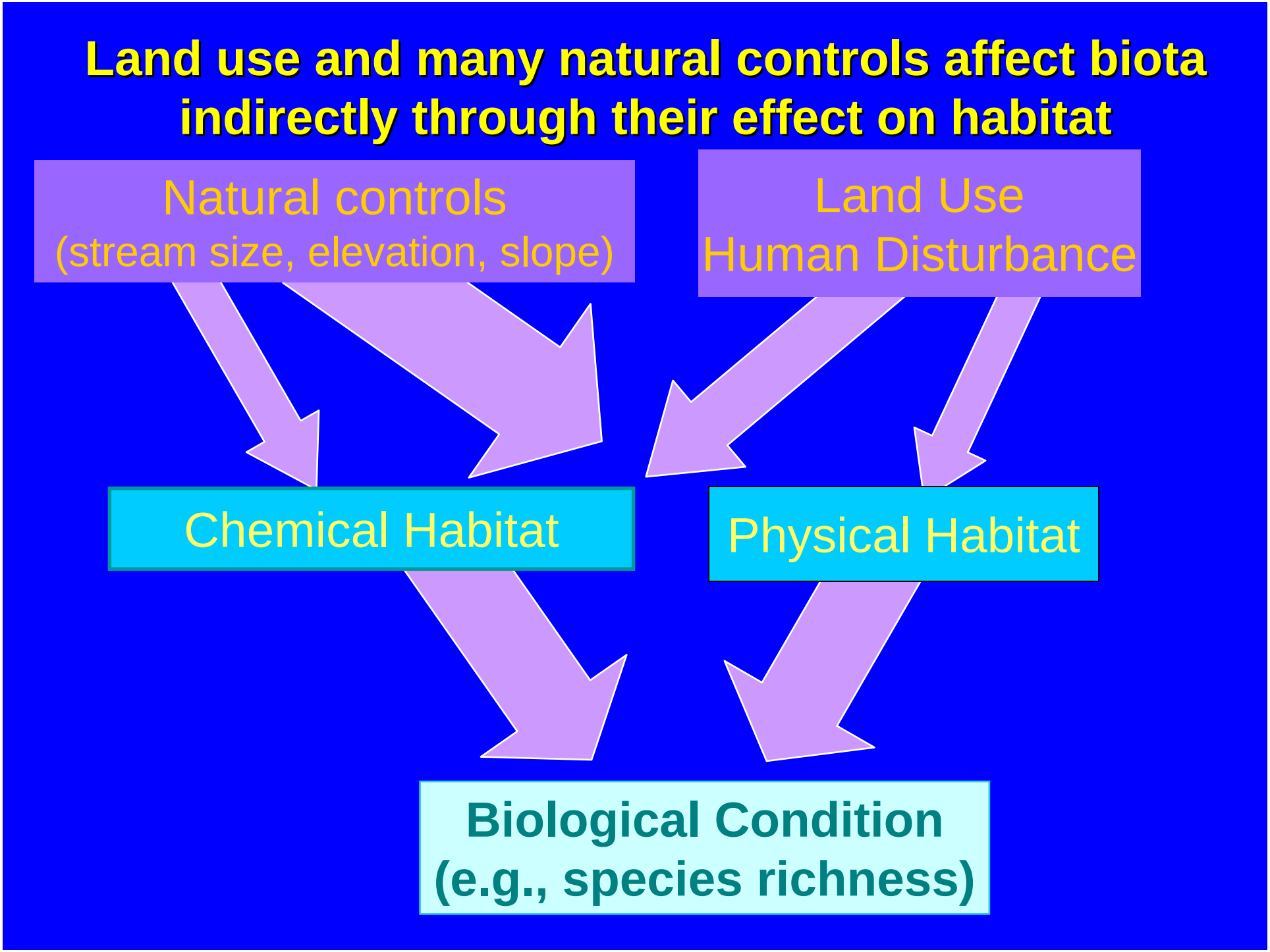
PHYSICAL HABITAT INDICATOR DEVELOPMENT

- Determine Aspects of Interest
- Define Metrics to Quantify Aspects
- Develop Field Monitoring Protocol
- Quantify Variability, Precision
- Demonstrate Ecological Relevance
  - Biological associations
  - Sensitivity to human disturbance

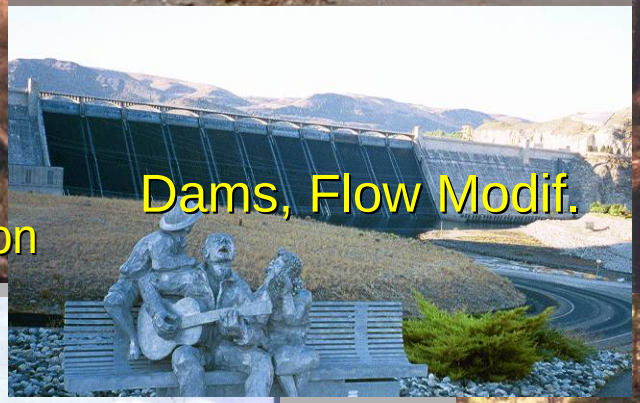
HABITAT... the set of conditions that support and control the distribution and abundance of aquatic organisms...

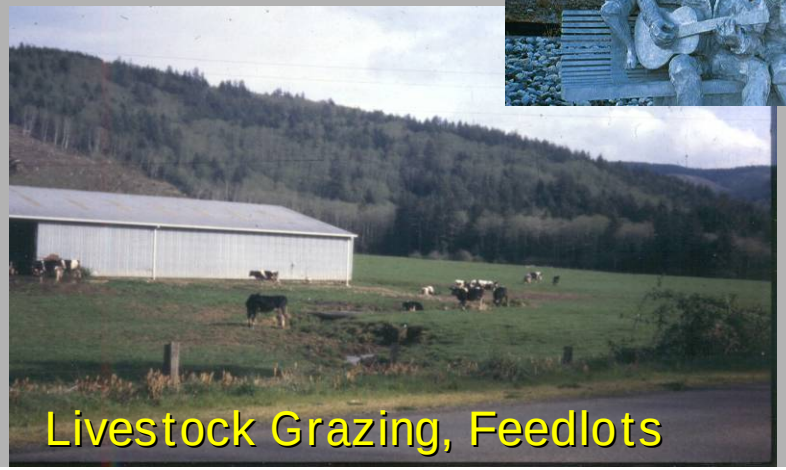
- Physical : Typically restricted to physical habitat structure
  - Includes some "biological" elements like vegetation that affect structure
- Chemical
- Biological
- Consider Landscape and Historical Contexts
  - Measurements made at several spatial scales
  - Attempt to measure attributes that integrate conditions over time

Land use and many natural controls affect biota indirectly through their effect on habitat



We alter river habitat in many ways





What will a sample of non-wadeable rivers and streams look like?

- Width, depth, etc.

Selected Characteristics (25-50-75%) of Non-Wadeable Sample (EMAP-W & MAIA)

• Width (m)	30 44 61	33 66 129
• Slope (%)	.12 .36 .64	.19 .30 .55
• Thal.Depth(m)	1.0 1.4 2.1	0.9 1.4 3.0
• Reach L(km)	2.9 4.3 6.1	1.6 2.6 4.2
• Log(Dcbf-thal)	1.3 1.7 2.1	1.4 1.7 2.0
• Log(RBS-thal)	-1.4 -0.4 0.2	-2.5 -1.3 0.2
• Thalweg %SaFn	1 10 67	2 45 98
• FishCvr-Nat(%)	10 15 28	19 33 56
• FishCvr – LWD	0.4 3 19	2 6 12

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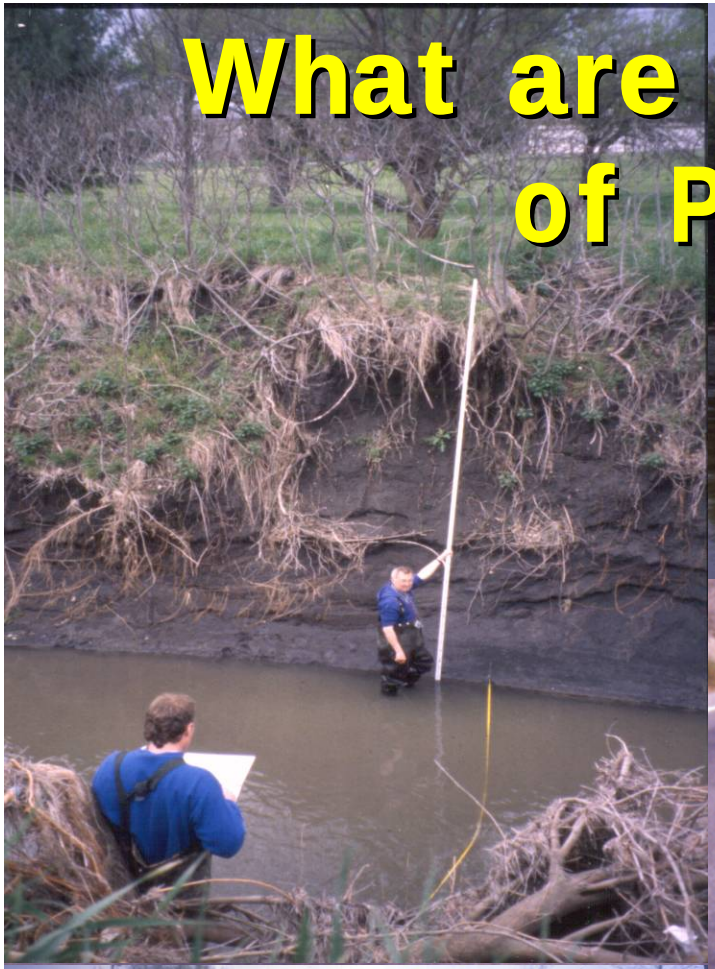
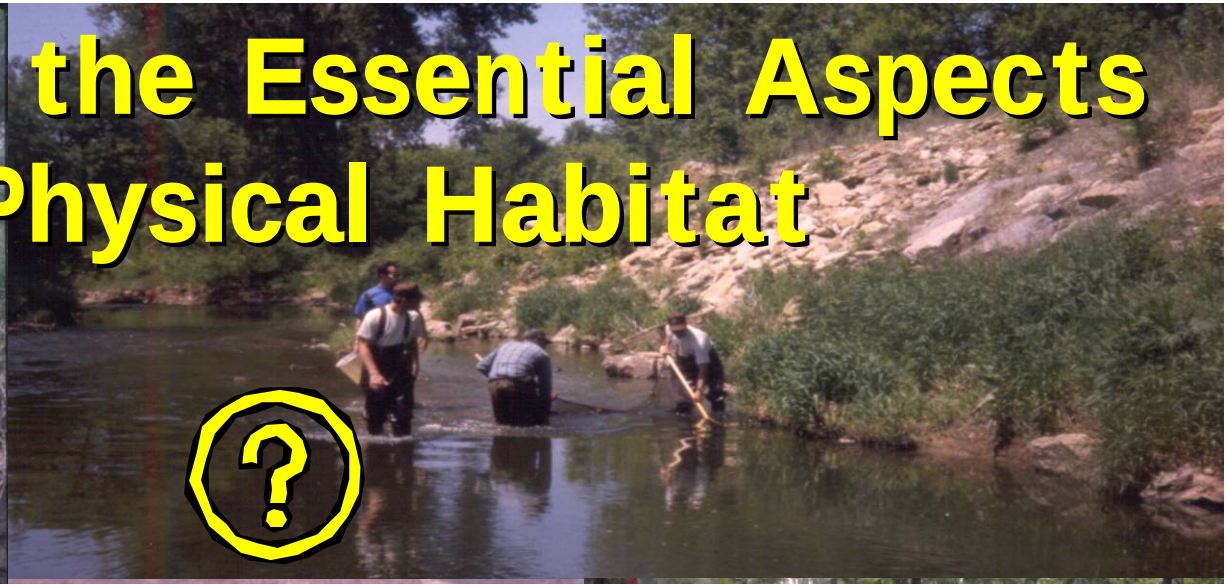
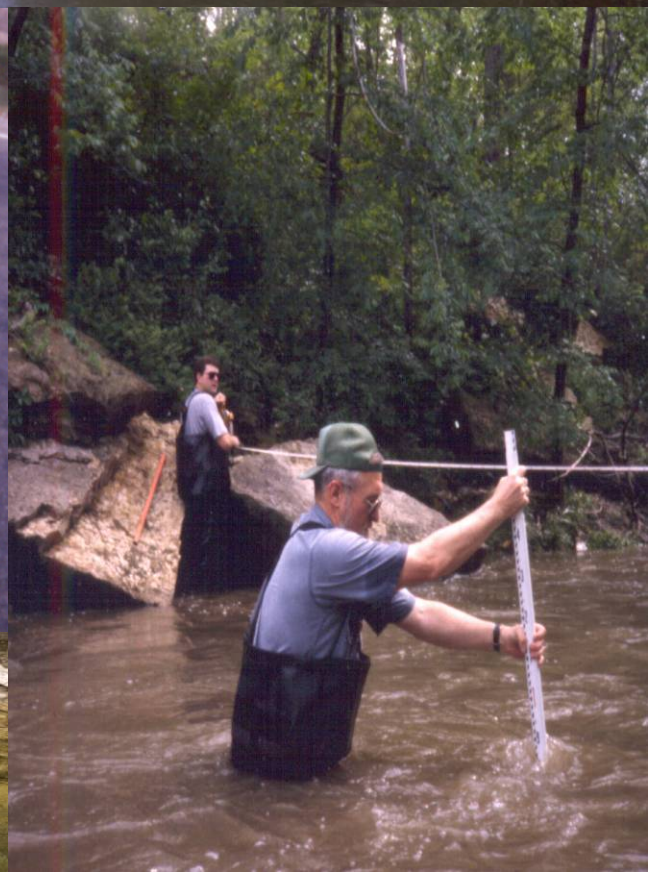
What are the Essential Aspects of Physical Habitat







Essential River Physical Habitat Elements

- Habitat “Size” (Channel Dimensions)
- Flow Regime
- Gradient
- Substrate
- Complexity & Cover
- Riparian Vegetation
- Channel-Riparian Interaction
- Anthropogenic Alterations

Essential River Physical Habitat Elements

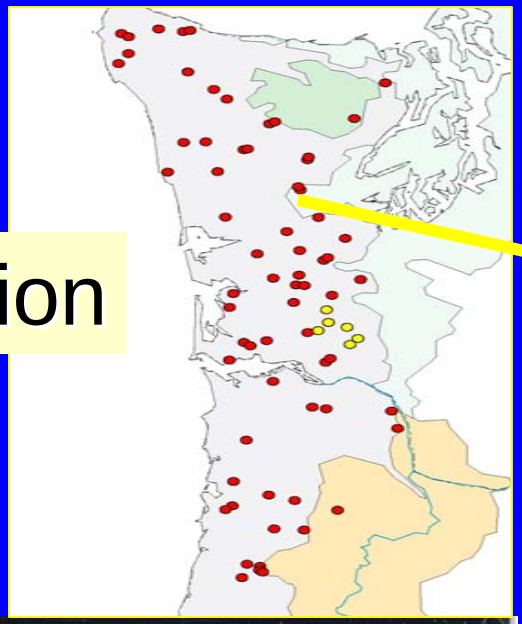
- Habitat "Size" (Channel Dimensions): Perhaps nothing is as important as habitat area and volume
  - If inadequate -- other elements do not matter
- Flow Regime: Determines the amount and timing of habitat space available and its water velocity – in turn influencing temperature, chemistry, sediment transport.
- Gradient: hydraulic "energy" of a stream
  - used with size to determine stream power and shear stress, which influence sediment transport and channel morphology.
- Substrate Size and Type: Large influence on habitat quality for fish, benthos, periphyton – also is raw material for channel structure.

Essential Stream Physical Habitat Elements

- Complexity & Cover: Niche diversity, protection from predation
- Riparian Vegetation Cover and Structure: influence temperature, organic inputs, channel morphology.
- Channel-Riparian Interaction: Important role for high and low flow refugia, spawning areas, etc. Channel characteristics are altered by riparian and catchment land use, which in turn influence terrestrial-aquatic interactions and velocity regime.
- Anthropogenic Alterations: help to diagnose stream disturbance and "reference condition"

Sampling over a range of spatial scales

Region



Measures of river physical habitat elements

- Habitat "Size" (Channel Dimensions): Wetted width, Bankfull width, Depth, Bankfull depth, Residual depth.
- Flow Regime: Mean annual discharge, seasonal pattern, flood magnitude and timing, ratio of bankfull/low flow channel dimensions, shear stress.
- Gradient: Field, DEM, or Map gradient
- Substrate Size and Type: Thalweg and littoral particle size distribution, Relative bed stability

Measures of River Physical Habitat Elements

- Complexity & Cover: Side channels, Alcoves, Snags, LWD, Brush, Aq. macrophytes, Filamentous algae, Rock ledges, Undercut banks.
- Riparian Vegetation Cover and Structure: Areal Cover of various types of vegetation, alien species, size of largest (legacy) trees.
- Channel-Riparian Interaction: Sinuosity, Bankfull height, channel incision, channel constraint.
- Anthropogenic Alterations: Direct evidence of human land and water use, channel/bank alteration, impoundment, flow withdrawal or augmentation

Adequate Habitat Indicator?

- Accurate & Responsive -- Does it measure what we intend ?
- Precise -- Can we separate changes or differences from measurement error?
- Relevant -- To Biological needs? Ecological processes? Societal values?
- Practical -- Can we do it? ...afford it?

PHYSICAL HABITAT INDICATOR DEVELOPMENT

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An Example of a River Physical Habitat Protocol that has been Widely Applied

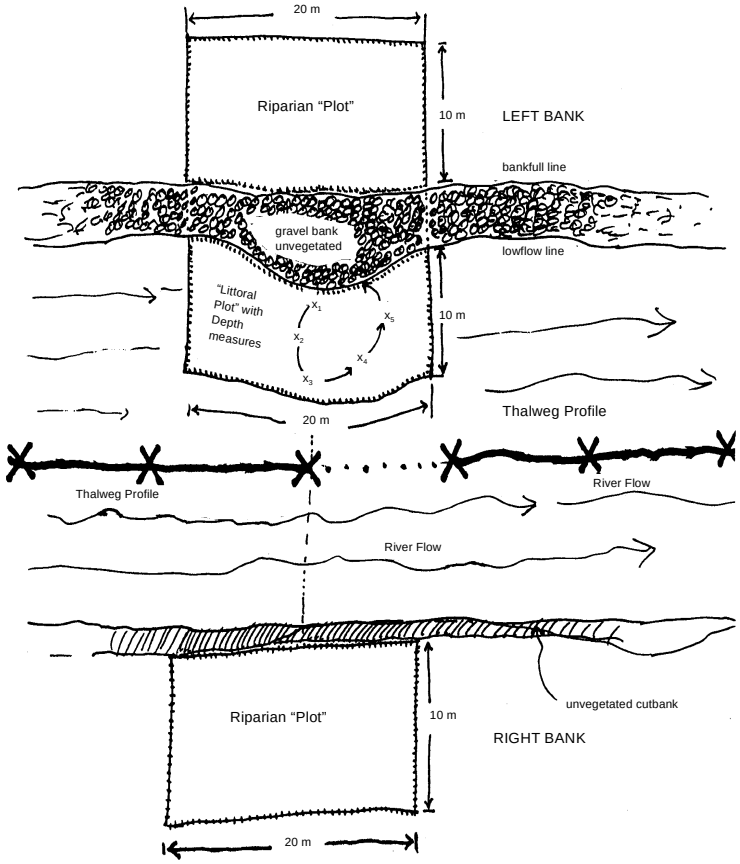
- EMAP-Rivers:

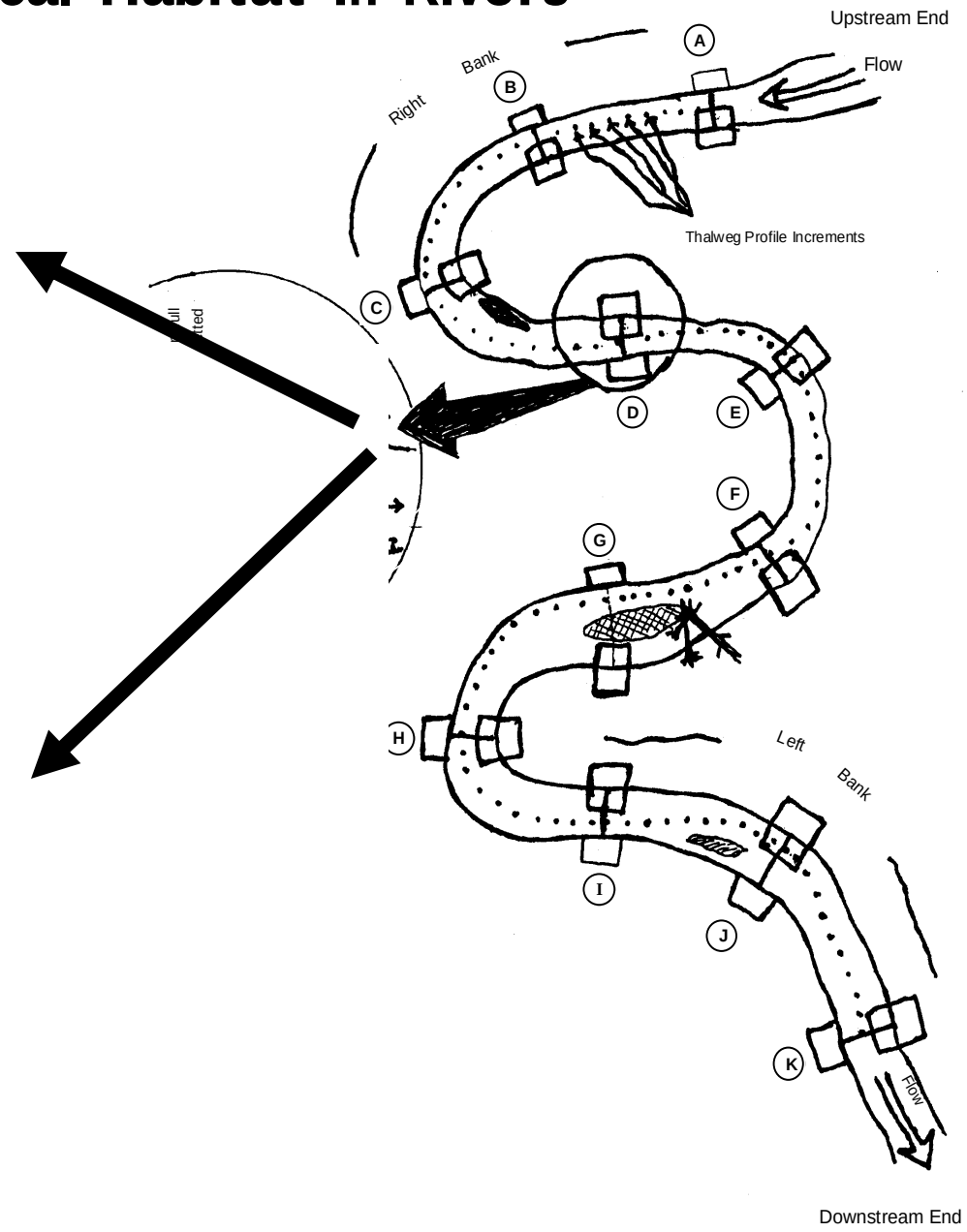
  pre-1997 --- protocol development
  1997-2006 – Effort-return studies

  1997------ 25 Oregon Rivers (pilot)
  1997-98 -- 60 Mid-Atlantic Region Rivers (pilot)
  2000-04 -- 200 Western US Rivers


• Protocol development constrained by need to limit sampling activities to a single, 1-day visit
• Needed to accommodate (and integrate) sampling and measurements for several different indicators (biological, habitat, chemical)
CRE
CRE

EMAP's Plot Design for Physical Habitat in Rivers

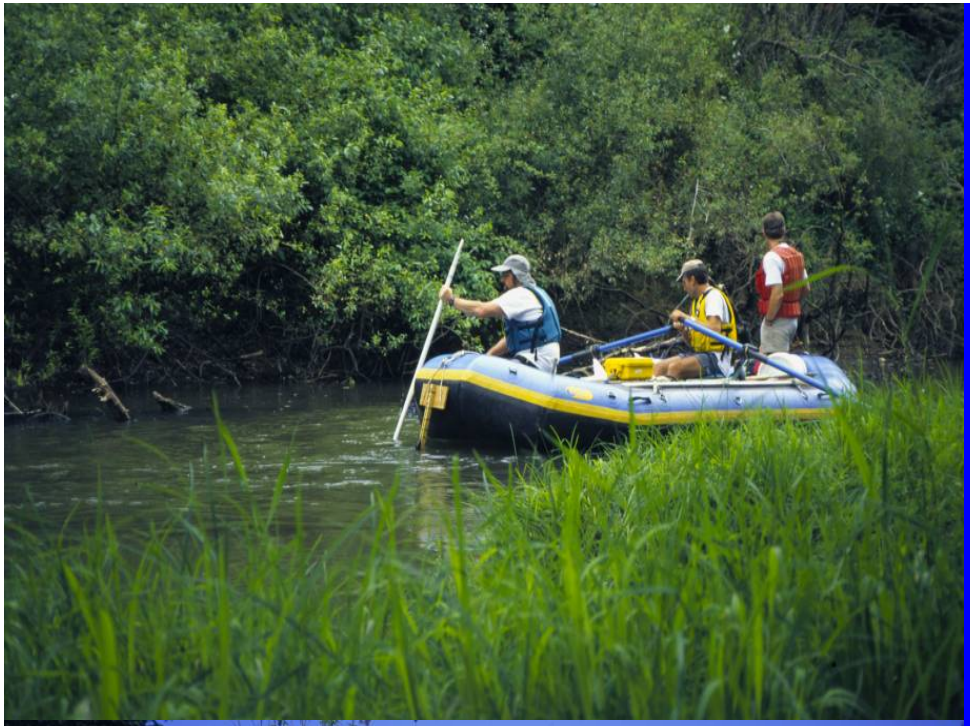




River P-Hab -- Can we do it? afford it?

- Best w/ crew of 2 on raft or inflatable kayak.
- Trained in several days.

- Takes 5 to 8 hours for measurements (depends on river size, location of put-in & take-out)
- First several rivers may take much longer.



EMAP P-Hab (Rivers):

Quantitative Measurements:

- Channel Dimensions
- Slope, Bearing, Bank Char.
- Near-Shore Canopy Density
- Thalweg/Littoral Depths

Visual Estimates/Tallys:

- Fish Concealment Features
- Woody Debris Tally
- Snags & Backwaters
- Rip. Veg. Cover/Structure
- Dom. Subdom. Substrate
- Human Disturbances
- Constraint

EMAP River Reach Physical Habitat Characterization

West: 100 Channel-Width Reach; (East: 40 ChW Reach)

Long Profile at 100 equidistant points:
-- Dominant Substrate, Main Channel Habitat Class,

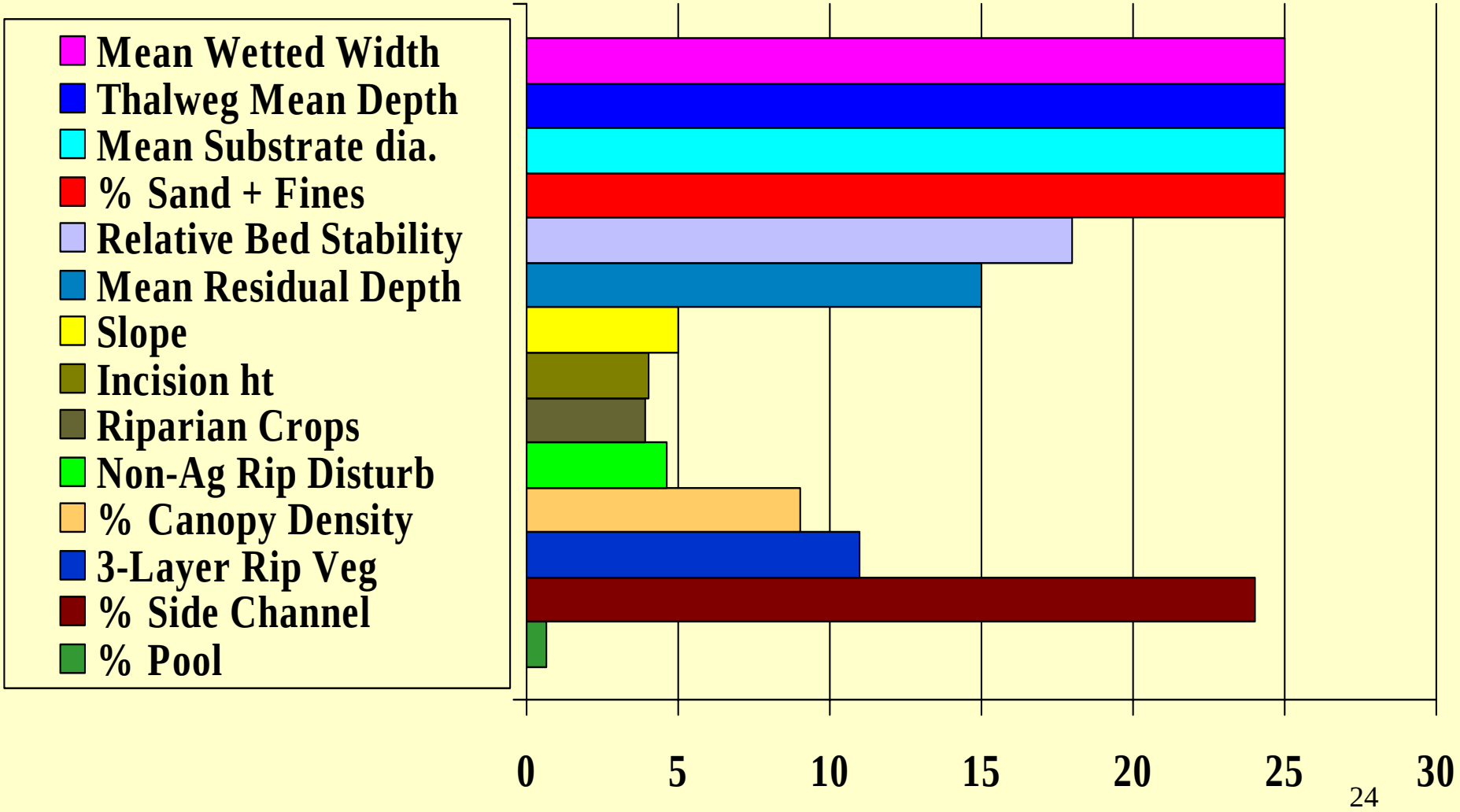
Long Profile at 200 (100) equidistant points:
-- Thalweg depth, Presence of snags
-- Presence of Backwaters & Off-Channel Habitats

11 Equidistant Cross-Sections and Littoral/Riparian Plots:
Channel Measurements: Slope, Bearing, Main Channel Dimensions, Mid-Channel and Point bar widths, Littoral Depth, Dominant & Subdominant Littoral Substrate, Fish Cover, Large Woody Debris.
Riparian Measurements: Bank Character, Riparian Vegetation Cover & Structure, Presence of Alien Invasive Plant Species, Size/Type/Distance to Largest tree, Human Disturbance, Dominant & Subdominant Substrate.

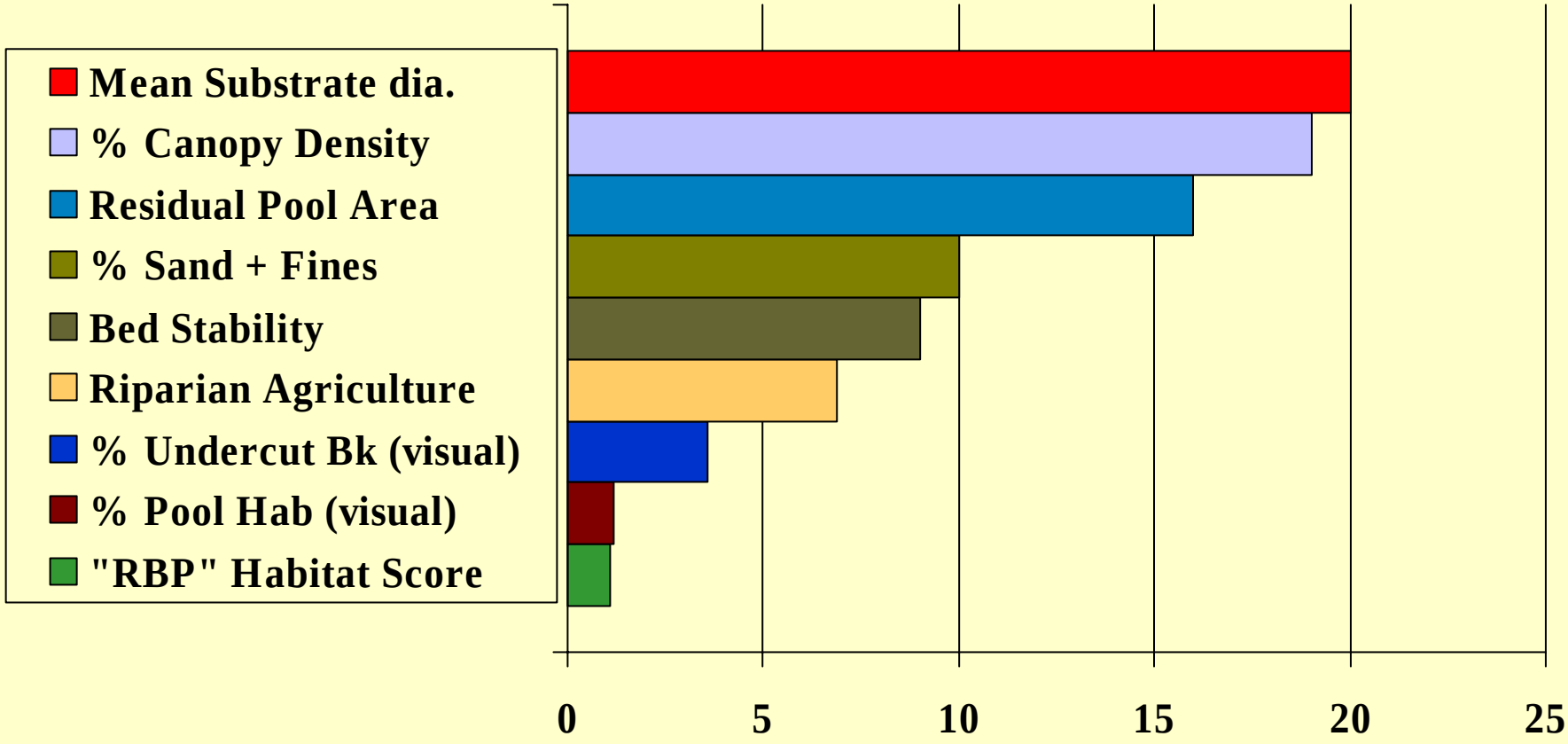
For the whole Reach:
Channel Constraint and Valley Width Assessment

Signal to Noise Variance Ratio
(EMAP-W) Rivers : Replicates

(graph truncated at S/N=25)



Signal to Noise Variance Ratio
(MAHA 93-96) Streams : Replicates



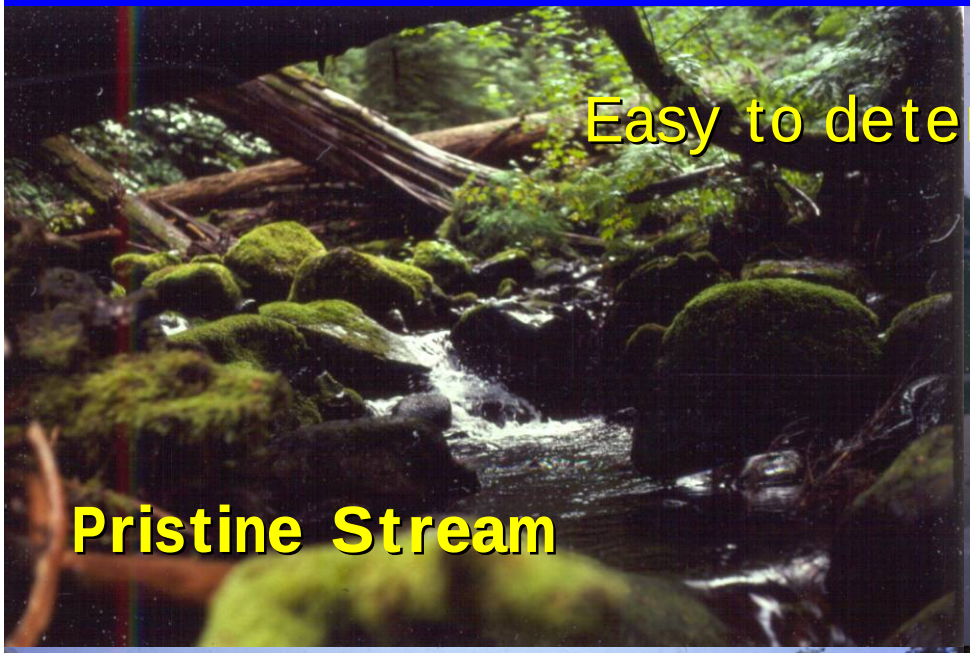
Effect of measurement precision on the maximum regression R^2 that could be observed between two variables measuring attributes that are actually perfectly correlated.

Variable 1 $\sigma^2_{strm}/\sigma^2_{rep}$

Variable 2 $\sigma^2_{strm}/\sigma^2_{rep}$	1	2	3	5	10	25	50	100
1	.50	-	-	-	-	-	-	-
2	.58	.67	-	-	-	-	-	-
3	.61	.70	.75	-	-	-	-	-
5	.65	.75	.79	.83	-	-	-	-
10	.67	.78	.83	.87	.91	-	-	-
25	.69	.80	.85	.90	.93	.96	-	-
50	.70	.81	.86	.90	.94	.97	.98	-
100	.70	.81	.86	.91	.95	.98	.99	.99

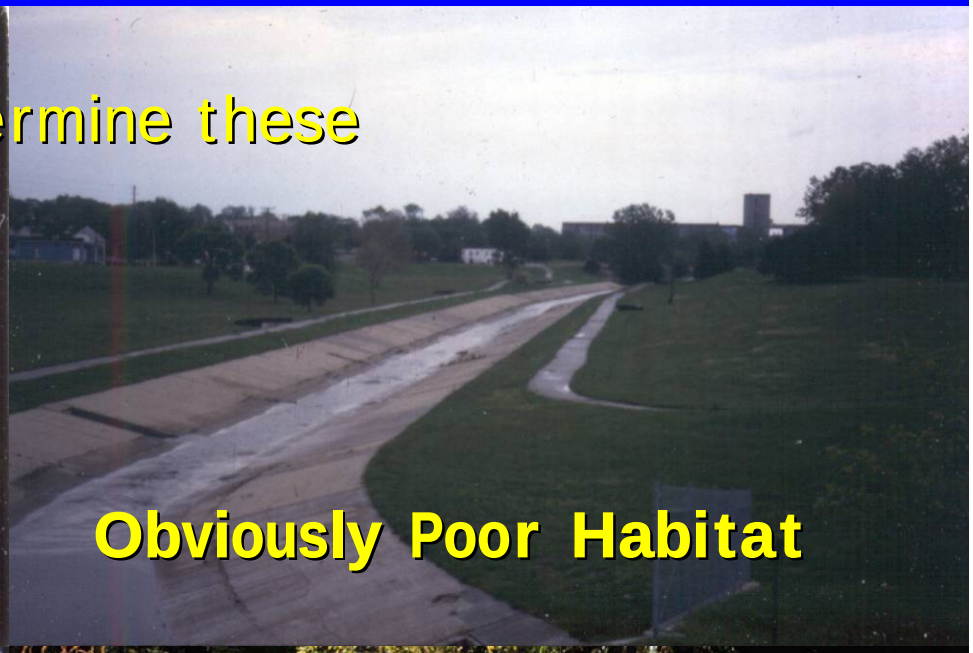
END

What Constitutes Good Habitat?



Easy to determine these

Pristine Stream



Obviously Poor Habitat

Need quantitative data for these

Somewhere in the middle

How good is this?

----------Stream Size ---------->

- - - - - - Gradient - - - - - - - - - - >

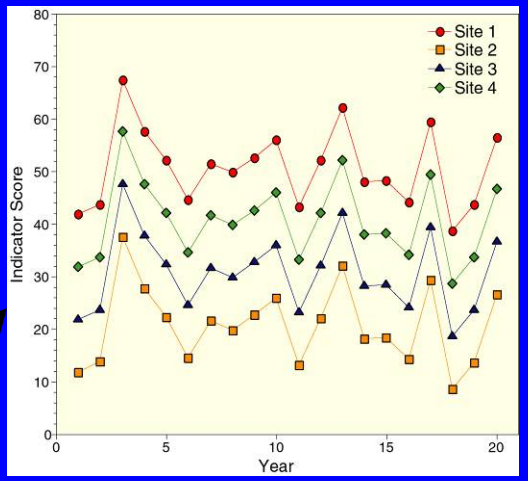
LANDSCAPE CONTEXT

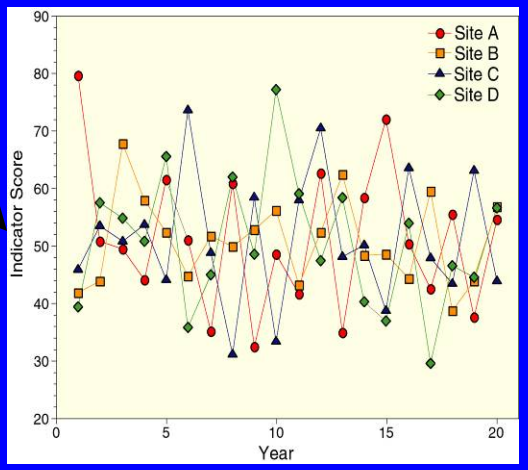
strongly controls habitat characteristics

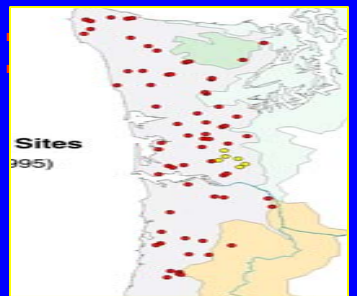
Natural “drivers” operating at different scales

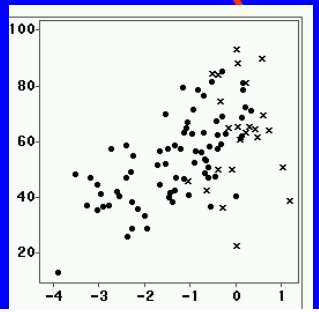
Precision: Quantified through repeat sampling

- Within same season ("noise)
  - "index" variance – combines measurement and within-season temporal variation
- Among Years (Year-to-year temporal variation)
  - Concordant: all sites vary together
  - Discordant: sites vary individually
- Variation Across Streams (the "signal"):

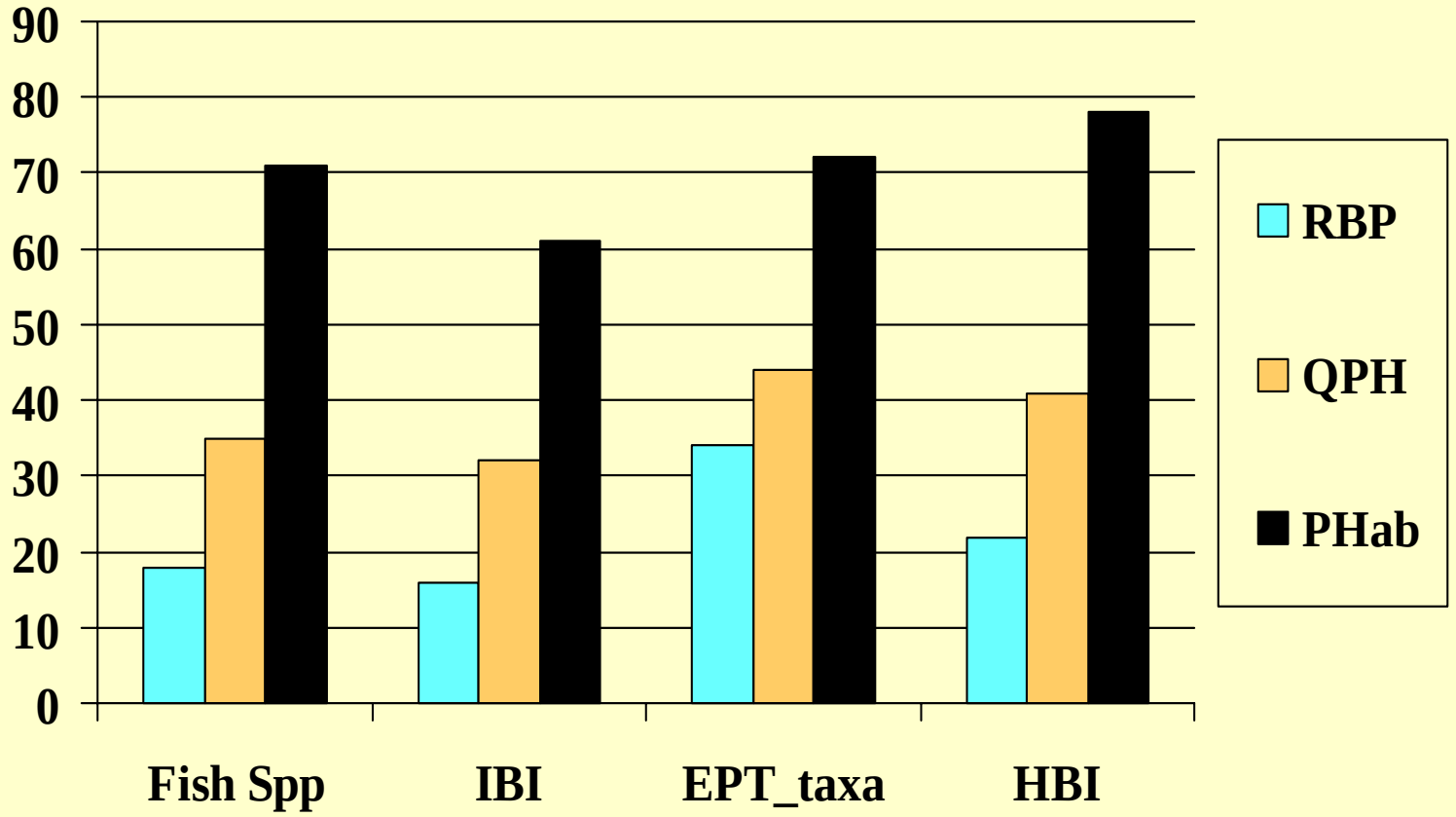








% Variance Explained Using Different Habitat Assessment Approaches in MLR



Mid-Atlantic Region Streams (7/97)

Trend Detection Potential (Stream P-Hab Variables)

- **How long for 50 site network (sampled 1x/yr) to detect 2% and 1% per year trends?**

	2%	1%
- Std.Dev Thalweg Depth ----------	8 yr	13 yr
- Mean Residual Depth ----------	12	20
- % Sand & Fines ----------	12	20
- % Embeddedness ----------	12	20
- Relative Bed Stability ----------	8	12
- Large Woody Debris Volume ------	16	25
- 3-Layer Rip. Woody Veg. Cvr. -----	8	12
- Canopy Density ----------	8	14

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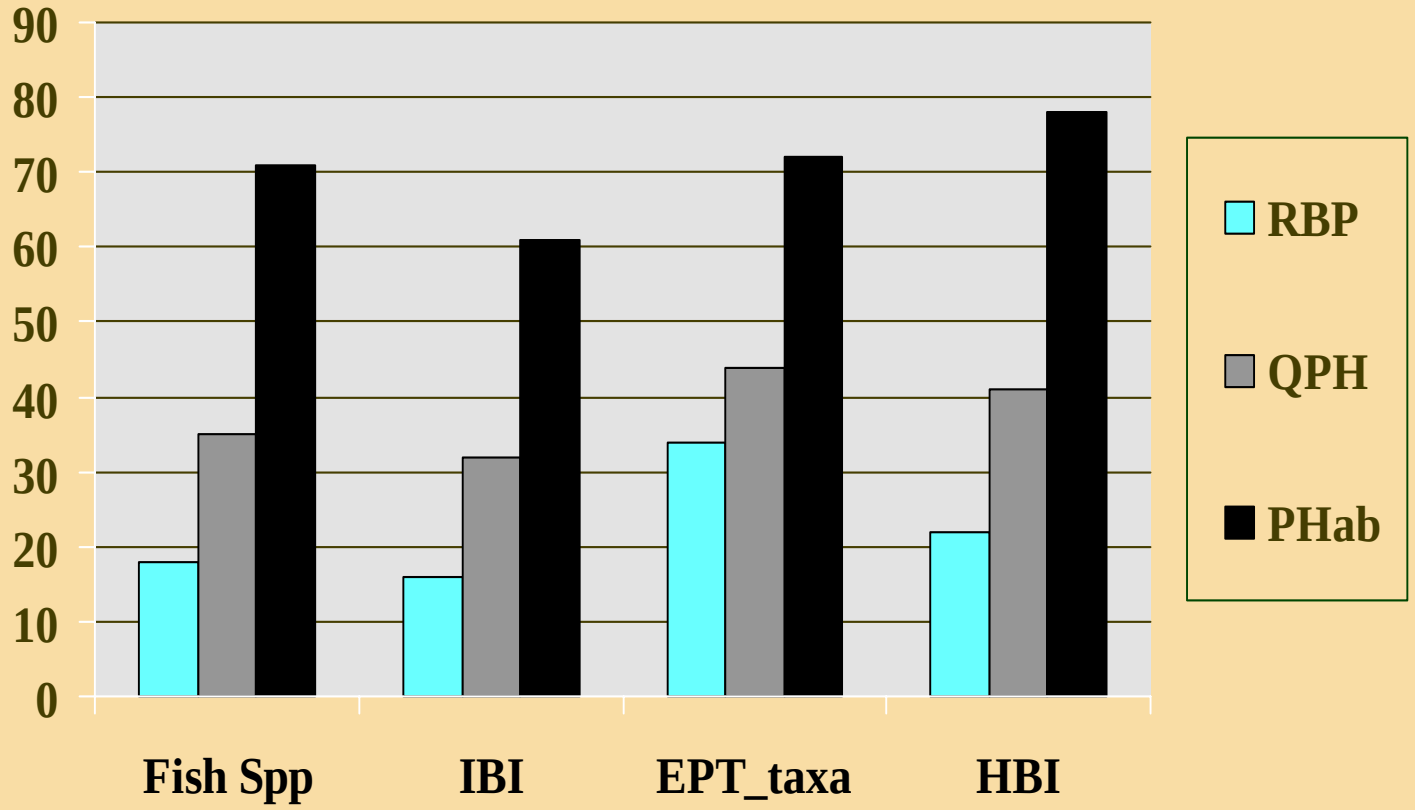
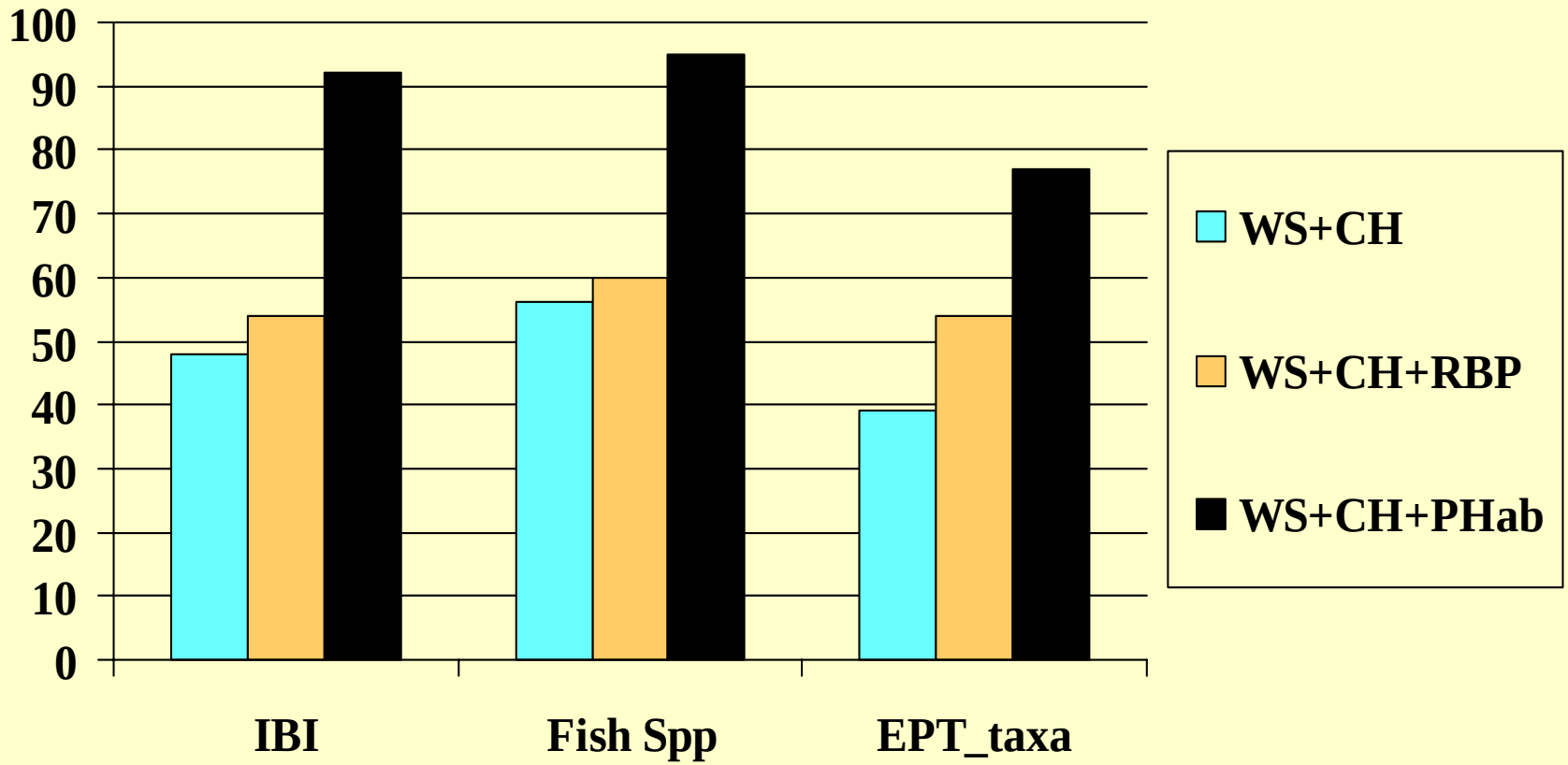
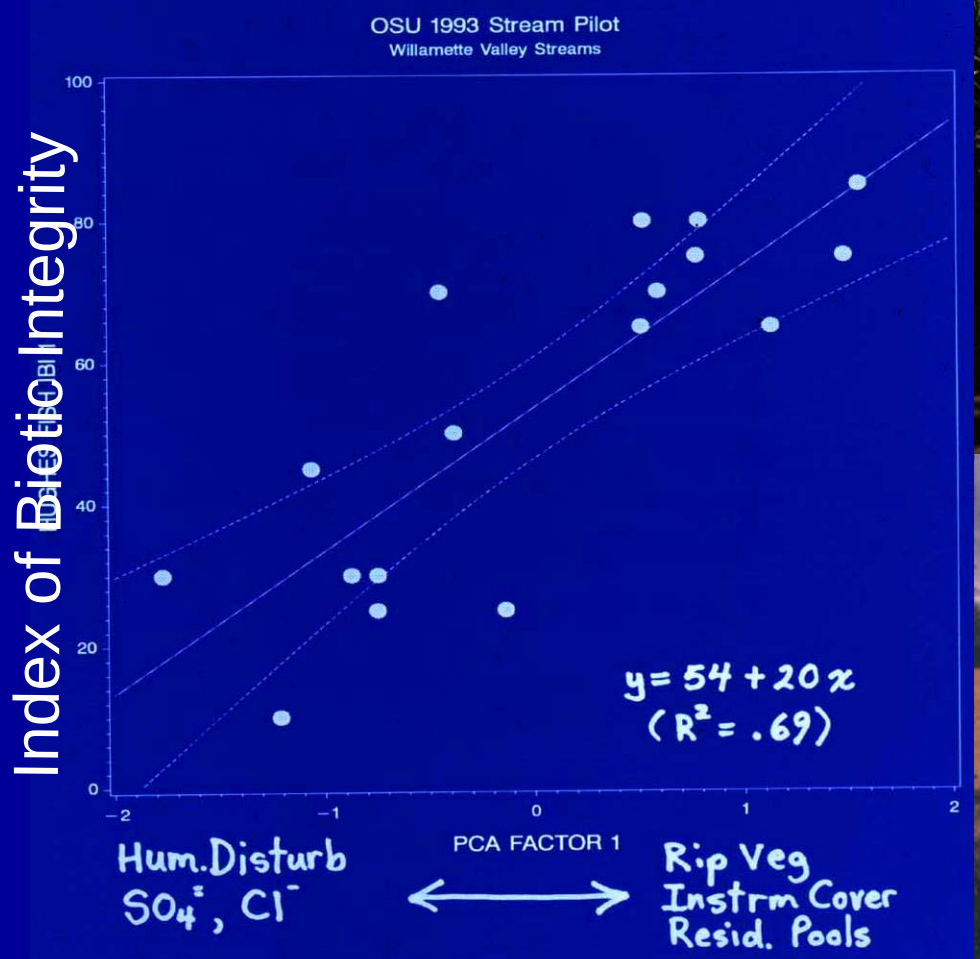


Mid-Atlantic Region Streams (7/97)

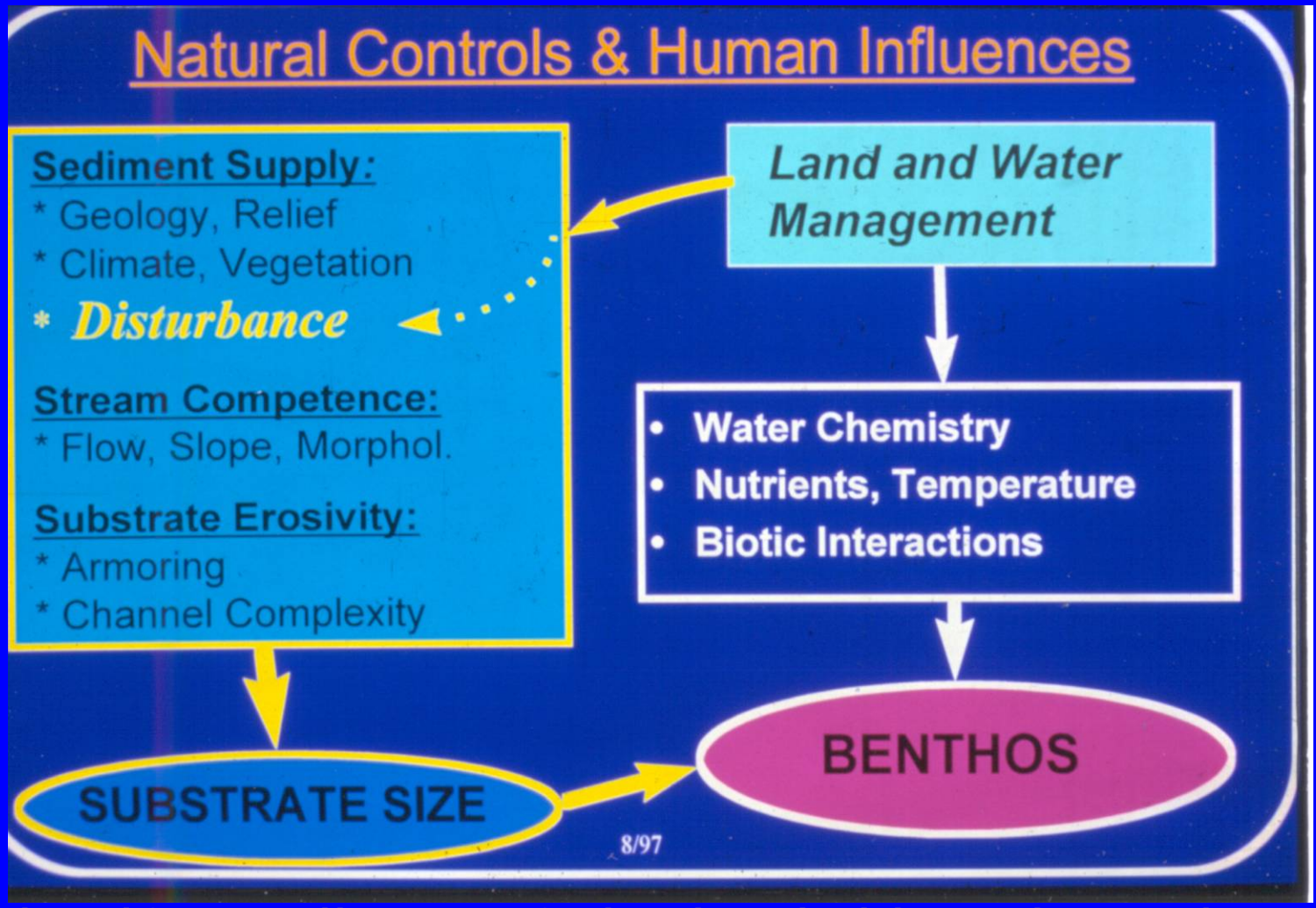
% Variance Explained Using Different Habitat Assessment Approaches in MLR



Mid-Atlantic Lowland Streams


OSU 1993 Stream Pilot
Willamette Valley Streams
Index of Biotic Integrity
IBI
100
80
60
40
20
0
−2
−1
0
1
2
y= 54 + 20 x
(R² = .69)
PCA FACTOR 1
Hum.Disturb
SO4=, Cl−
Rip Veg
Instrm Cover
Resid. Pools
Habitat Quality

END



- Identify attributes of physical habitat that adequately describe the major natural and anthropogenic controls on various biological assemblages
- Expected responses of habitat to various types of human disturbance